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Seed Potato Treatment Tests for Control of Scab and Rhizoctonia

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SUMMARY

1. The experiments here reported were conducted during the years 1926, 1927, and 1928. Those on scab control were made with the Irish Cobbler variety at Lincoln and North Platte and with the Triumph at Alliance. The Rhizoctonia tests were made with the Early Ohio variety at Lincoln.

2. The three locations used were considered representative of three different potato-growing sections of the state, the Lincoln plot representing the early potato section of eastern Nebraska, the North Platte plot representing the irrigated midseason section of south-central and western Nebraska and the Alliance plot representing the western dry-land commercial seed and table-stock region. The experimental plots consisted of 5 to 8 replications of 25-hill rows systematically distributed to equalize soil differences and competition.

3. The seed treatments tested included hot formaldehyde, mercuric chloride, and a number of commercial organic mercury preparations. These were used chiefly as dips on uncut seed. A few tests were made with cut seed and several organic mercury treatments were also applied as a dust. In addition, sulfur was tested as a soil treatment for scab during two years, acidulated mercuric chloride was used for scab control in one test, and treatments were made for Rhizoctonia control during two years, both with and without a presprinkle of water.

4. Hot formaldehyde was consistently the most effective treatment in controlling seed-borne scab. Mercuric chloride failed to control scab. The addition of 1.5 parts of HCl per 100 parts of mercuric chloride solution failed to increase its effectiveness. The organic mercury treatments applied either as a dip or a dust on either cut or uncut seed likewise failed to reduce consistently the amount of scab. Sulfur applied to the soil decreased the amount of scab in 1927 but failed to do so in 1926.

5. Seed tubers severely infected with scab and treated with hot formaldehyde equaled or exceeded the percentage of scab-free potatoes produced by apparently healthy seed untreated.

6. Apparently healthy tubers of the Bliss Triumph variety treated with hot formaldehyde produced more scab-free potatoes than such seed untreated.

7. With increasingly large amounts of infection from the soil of either scab or Rhizoctonia, the benefits from control of the seed-borne disease by seed treatment becomes progressively less.

8. There was no indication of reduced yields due to scab infection.

9. In the control of Rhizoctonia all the treatments resulted in increased yields. Hot formaldehyde gave the best control as judged by stem lesions and the sclerotia on the new tubers. Mercuric chloride and the organic mercurials were much more effective against Rhizoctonia than against scab, the mercuric chloride, however, giving the best results.

10. Presprinkling the tubers infected with Rhizoctonia 24 hours before treating with mercuric chloride failed to increase the effectiveness of the treatment. The small size of the sclerotia probably rendered this presprinkle treatment unnecessary.

11. In the Rhizoctonia tests with the Early Ohio variety, the hot formaldehyde retarded emergence in two of the three years and the beneficial effect due to disease control was not as evident when a period of hot, dry weather prevented the plants from overcoming the handicap of delayed emergence. Such injury did not occur in any of the 9 scab tests with Triumphs and Cobblers. The treatment of the seed a few weeks before planting is recommended to eliminate this retarded emergence.

12. The organic mercury treatments cause some seed-piece injury unless care is taken to allow the cut seed pieces to dry rapidly.

13. There was no consistent increase in yields resulting from seed treatment with the organic mercury compounds other than thru the control of Rhizoctonia. The organic mercury treatments did not increase stands or vigor nor did they prevent seed-piece decay in the one test recorded. No correlation was found in this test between seed-piece decay and vigor of the plants determined either as green weight of the tops or total yield.

14. Due to the fact that much of the seed planted in eastern Nebraska is infected with Rhizoctonia and in western Nebraska with scab, the hot formaldehyde treatment is a profitable investment, to be recommended for all seed potatoes.

Seed Potato Treatment Tests for Control of Scab and Rhizoctonia

R. W. GOSS AND H. O. WERNER

Potato scab annually takes a very large toll from the potato growers of Nebraska. Scabby potatoes of marketable size, which have to be culled out, when conservatively estimated amount annually to between 15 and 25 per cent of the crop. Rhizoctonia causes considerable loss each year, particularly in the early-potato sections, where it decreases stand and yield. These losses are caused by infection from both the soil and the seed. The investigations reported in this paper deal only with the control of the infection arising from the seed.

Even tho potato seed treatments have been recommended for many years, the diversity of recommendations being made at present by various agencies is very confusing to the grower and research worker alike. Many of the reports from different parts of the United States have been quite contradictory and a survey of the literature indicates that in many cases the conflicting results may have been due to local conditions. It was the purpose of the present investigations to determine the relative value of various seed treatments under the several conditions existing in the potato-growing sections of Nebraska.

Prior to 1926, when these tests were started, it was commonly observed that the cold mercuric chloride treatment was not very satisfactory and was not giving as good results in Nebraska as had been reported from other states. Many growers had abandoned the use of this treatment because it did not control scab. The hot formaldehyde treatment, devised and recommended by Melhus and Gilman (9) in Iowa, had the distinct advantage of shortening the length of time required for treating from 1½ hours to from 2 to 4 minutes. Neither of these treatments had been tested experimentally by the Nebraska Experiment Station. Several organic mercury compounds on the market that appeared to have some desirable features were included in order to determine their effectiveness under Nebraska conditions. While the chief purpose of the experiments was to test the above-mentioned treatments, a few other treatments were added as time and space permitted.

It was at first considered desirable to continue all tests for at least three years before attempting to draw definite conclusions. Later it was found that this was not possible or advisable with all treatments, due to the fact that certain commercial treatments tested one year were not available the following year since by that time they had been replaced by other preparations purported to be more effective. Other minor changes in the methods of experimentation were made but the basic methods used were carried out thru all three years so that the data would be as comparable as possible.

The uniformity of the results obtained was such that definite conclusions can be made regarding the relative effectiveness of the various treatments tested. The work has therefore been discontinued and the results which have been partially reported elsewhere (4) are here reported in full.

METHODS OF EXPERIMENTATION

LOCATION OF PLOTS AND CULTURAL CONDITIONS

The experiments were conducted at three different locations, which are representative of three of the principal environmental conditions under which potatoes are raised in Nebraska.

Plot 1. Lincoln.—This plot, located on the Experiment Station Farm, is representative of the early potato crop grown for home consumption in eastern Nebraska. The crop, planted between April 1 and 15 at an altitude of approximately 1,200 feet, is usually under conditions of low temperature and fairly high precipitation during the emergence period and shortly after, but it often suffers from hot, dry weather during the later period of tuber formation. This sometimes results in the death of the vines from 1 to 4 weeks before normal maturity.

Plot 2. North Platte.—This plot, located at the North Platte Substation, represents the early commercial irrigation region. As the altitude at North Platte is about 2,800 feet, the crop, while planted in April, does not usually suffer from high temperatures during the period of tuber formation. It is also supplied with sufficient moisture by ditch irrigation.

Plot 3. Alliance.—This plot is representative of the westtern Nebraska dry-land commercial seed and table-stock region where potatoes are raised as a late crop, planted in June. At Alliance lower temperatures prevail than at the other points, due to the higher altitude (about 4,000 feet). The annual rainfall is in the neighborhood of 19 inches. The experimental plot was located on the same farm in 1926 and 1927 but on a different farm in the same locality in 1928.

SIZE AND ARRANGEMENT

The various treatments tested in each plot were replicated from 5 to 8 times, except the untreated checks of healthy and scabby seed, which were replicated twice the number of the treated lots. Each replication consisted of a single 20- or 25-hill row. The treatments were distributed thru the plot by use of a modified "Latin square" system. By the use of this system of planting the possible variations in soil infestation as well as in nutrients, moisture, temperature, texture, reaction and culture are largely compensated for by the uniform distribution of the tests thruout the plot. In addition, the factor of competition and its effect upon yield is partially equalized by the position of the several replications, which are so arranged that each treatment is adjacent to every other treatment somewhere in the plot.

FIELD METHODS

All seed pieces were cut to a uniform size of one-tenth of a pound. In all except one instance (Plot 3, Alliance, 1928) the seed was hand-planted. Hills were spaced 15 inches apart with rows 3 feet apart, except at North Platte in 1927 and 1928 when the hills were spaced 12 inches apart.

The Lincoln plot was planted about the middle of April and harvested the last week in August. The North Platte plot was planted about April 20 and was harvested September 1 in 1926, October 7 in 1927, and October 1 in 1928. In 1926 the plants at North Platte were mature about August 15, in 1927 by September 1, and in 1928 about August 1. The Alliance plot was planted the first week in June and harvested the first week in October.

SEED

Irish Cobbler potatoes, grown in Minnesota or western Nebraska, were used for the scab experiments at Lincoln and North Platte. This variety is the most practical for commercial midsummer production in those regions. Western Nebraska certified Triumph potatoes were used for the scab tests at Alliance, this variety being the predominating one in the western part of the state. In the Rhizoctonia tests, Early Ohio seed from the Red River Valley was used, as this is the most common source of Early Ohio seed for eastern Nebraska plantings.

The scab on the Irish Cobblers was of the common surface type, with but a small amount of pitted or deep scab. On the Triumph variety the scab was much more severe, due to the presence of more lesions, which were both larger and deeper than on the Irish Cobbler seed. All seed listed as healthy was carefully washed and examined and did not contain any tubers with visible scab lesions or Rhizoctonia sclerotia. Because of the darker color of the skin and the more severe scab infection of the Triumph seed, it was probably impossible to secure as clean seed for the healthy lot of that variety as for the lot of Irish Cobbler.

The Rhizoctonia on the Early Ohio seed was mostly in the form of small sclerotia (from 1 to 3 mm. in size) which were well scattered over the surface.

The seed used in each plot for any series of treatments was always from the same source for both healthy and infected lots and also for both the treated lots and the untreated checks.

SEED TREATMENTS

The various treatments used and the methods of employing them are listed in the tables. A few notes concerning these treatments, which cannot be included in the tables, will be given here.

In Plots 1, Lincoln, and 3, Alliance, all the seed treatments were made either the same day or the day previous to planting, unless otherwise noted. The seed treatments for Plot 2 were usually made at the same time as for Plot 1 and were treated and cut before shipping. This required holding the seed from 7 to 10 days after cutting. As Cobblers were used in Plot 2, and as the cut surface of this variety heals over quickly, this system was found to be entirely satisfactory. In the other plots it was necessary in one year to hold cut seed a few days before planting, due to unfavorable weather.

All the seed for each treatment in a plot was treated at the same time. All seed of any one treatment was cut into the required number of seed pieces of equal weight and was then divided at random into the desired number of replications. This method gave a fairly good distribution of seed pieces from individual tubers thruout the different replications. Cutting was generally done after the seed had been treated and allowed to dry.

Treatment of healthy seed.—In addition to the untreated healthy checks, it was advisable to include some treatment of healthy seed to determine the amount of disease being carried on the tuber in a form not visible to the naked eye. Such a check also served as a basis for determining more accurately the amount of soil infestation and also as a basis of comparison when used on infected seed for all the other treatments.

In 1926 the cold mercuric chloride treatment was used for this purpose, being employed as a 1-to-1,000 solution in which the potatoes were dipped for 1½ hours. The results obtained in 1926 indicated that the hot formaldehyde treatment might serve as a better basis of comparison and it was therefore used in 1927 and 1928. This treatment was employed as a 1-to-120 solution in which the potatoes were dipped for 4 minutes at a temperature of 122° to 124° F., after which they were covered for one hour and then allowed to dry.

In addition to these checks it was deemed advisable, in 1928, to include one of the organic mercury treatments to test the possible effect on yield, exclusive of possible yield effects due to scab control. Accordingly, one lot of healthy seed was treated with Semesan Bel and another lot was first treated with hot formaldehyde and afterward treated with Semesan Bel. The Semesan Bel treatment was made on whole seed as an instantaneous dip with a 1-to-20 dilution.

In selecting the healthy checks for the 1926 tests in Plots 1 and 2, it was found impossible to obtain enough healthy tubers to provide the double number of replications desired. Potatoes were therefore selected for one set of replications with as few scab spots as possible and tested untreated and with the mercuric chloride treatment. These are listed in the tables as slight scab. The results obtained made it desirable to include an untreated lot of similar seed the next year as a check upon the results.

Treatment of scabby seed.—In addition to the hot formaldehyde and mercuric chloride treatments, a number of organic mercury compounds and acidulated mercuric chloride were tested at various times.

Among the organic compounds Semesan Bel as a dip was used in every plot each year and Bayer Dip Dust was used each year in all the plots with the exception of the 1926 plots at Lincoln and North Platte. Additional organic mercury compounds were used during the various years as follows: in 1926, Du Pont No. 12; in 1927, Du Pont D. D. D. No. 2 and Bayer 181; and in 1928, Du Pont 76B and Bayer 190. The dip treatments were made at the strengths indicated in the tables. The dilution was made by slowly shaking the dust into the required amount of water while rapidly whipping the liquid with a beater made of heavy wire. This was found to be an excellent way of obtaining a good mixture without any caking or lumping of the material and resulted in a minimum amount of sediment. The dust treatments were made by thoroly shaking the potatoes and dust in a container until the surface of each tuber was thoroly covered. In 1927 the organic mercury dips were used on cut seed potatoes, the seed pieces having been allowed to heal for 18 to 24 hours before treating and also allowed to dry after treating and before planting. Unfavorable weather conditions caused a delay in the planting of the Lincoln and North Platte tests in 1927 and this caused some damage to seed pieces with some treatments as will be noted later. In 1926 and 1928 the organic mercury treatments were made on whole (uncut) tubers.

Inasmuch as no data were available as to the possible effects of a sulfur treatment of the soil under Nebraska conditions, this treatment was also included in the 1926 and 1927 tests. Inoculated sulfur was used only in 1926. In all the tests sulfur was applied to the soil by distributing it evenly along the furrow before planting at the rate of one ounce per hill, calculated to be approximately 600 pounds per acre.

In the 1928 tests at Alliance, Plot 3, one additional treatment was used by acidulating the standard mercuric chloride with the addition of HCl at the rate of 1.5 parts per 100. The treatment was used exactly as with the unacidulated.

Treatment of Rhizoctonia seed.—Many of the treatments used in the scab tests were also used in a similar manner for the Rhizoctonia tests. The sulfur tests and the acidulated mercuric chloride test used in the scab experiments were omitted.

In 1926 two tests were made with the presprinkling method advocated by Raeder, Hungerford, and Chapman (12). In these tests the seed was dipped in water and after being drained was covered for 24 to 48 hours and cut before treating with mercuric chloride or Du Pont No. 12 Bel Dip. All other treatments in 1926 were made on uncut seed.

In 1927 all the organic mercury tests were made on cut seed, handled as in the scab tests. Another test with the presprinkle method using mercuric chloride was included.

In 1928 all tests were made on uncut seed with the exception of one-half of the extra replications used for a count of stem lesions and notes on preservation of seed pieces as indicated in Table 7.

METHODS OF HARVESTING AND RECORDING RESULTS

Emergence records were taken twice weekly. Notes on the relative vigor of the plants with the various treatments were made each year. In 1928 special effort was made in determining the vigor of the vines in relation to seed-piece preservation, total weight of green tops, and final yield. The methods used will be presented later with the discussion of results.

Each replication of a treatment was dug and sacked as a unit and later was graded over a commercial grader into U. S. grade sizes.

Disease records. Scab.—In recording the amount of scab present, each replication of 20 or 25 hills was considered as a unit. After being graded by sizes, the tubers were examined individually for scab lesions and classified according to the severity of infection into the following five scab classes:

Class 0—scab-free tubers
Class 1—less than 5 lesions 1/8 in. or 1 lesion 1/4 in. in size
Class 2—more scab than Class 1 but less than 1/4 the surface scabby
Class 3—from 1/4 to 3/4 of the surface scabby
Class 4—more than 3/4 of the surface scabby

In 1927 and 1928 Classes 3 and 4 were combined and the results for 1926 are presented on this basis. Also, only the potatoes of U. S. No. 1 and No. 2 sizes were graded for scab. Inasmuch as there is always a possibility that small pin-head scab lesions escape detection, the greatest error undoubtedly occurred in differentiating between Classes 0 and 1. Since most of the potatoes in Class 1 would be graded commercially as healthy, these two classes have been combined in many of the following tabulations as "commercially healthy or scab free."

Rhizoctonia.—In 1926 the tubers were graded for size as in the scab experiments and then classified in 4 groups:

Class 1—healthy
Class 2—slight infection, *i.e.*, a few small sclerotia
Class 3—medium infection, *i.e.*, a few large sclerotia or many small ones
Class 4—severe infection, *i.e.*, most of the surface covered with sclerotia

In 1927 no records were made of the sclerotia on the tubers. The effects of the disease and of the treatments were measured solely in yield.

In 1928, in addition to yield data, the effect of the treatments was also measured by the number and severity of stem lesions. Six additional replications of 25 hills each were planted for every treatment. The hills in the different replications were dug on three different dates. The stems of each individual hill were carefully examined after washing and were graded as healthy or of slight, medium or severe infection, the latter referring to girdling. Notes were also made of the condition of seed pieces and the number of sprouts killed before emergence. The disease readings were made both on a hill and on an individual-stem basis.

Tabulations.—It is, of course, impossible to present the complete data on all of these tests. Inasmuch as the amount of scab did not vary greatly in the different sizes, only the No. 1 size potatoes will be considered with the exception of Fig. 1, which is presented as a typical instance of the distribution of scab in relation to tuber size and the yield of No. 1 size in relation to total yield.

In Tables 3, 4, and 5 the results of the scab tests are presented for the three years in each plot. The data in these tables are based upon the percentage of commercial scab-free potatoes rather than upon actual yields because, as will be pointed out later, the yield differences were not significant. The percentages shown in the first column of figures are the mean percentages obtained from the percentages determined for each replication. The formula used for calculating the probable error of the mean was PE of $M = \frac{0.6745}{\sqrt{N}}$. The next column gives the ratio of the differences between the treated lots and the untreated scab check, and the probable error of the differences, which is calculated as follows: PE of Diff. $= \sqrt{PE^2x + PE^2y}$ (when x and y refer to the two means).

In order to conserve space, all of the yield data on the scab experiments are presented in Table 2. The difference between the mean yield of each treatment and that of the untreated scabby potatoes and the probable error of the difference are given, and also the ratio of the difference to the probable error of the difference. The actual yield of the untreated check, upon which the differences are based, is also given.

RESULTS

SCAB EXPERIMENTS

Emergence and stand.—The effect of the various seed treatments upon the rate of emergence and final stand during the entire three years is typified by the results presented in Table 1 for the year 1928. The outstanding point of interest in this table is the depressing effect on the rate of emergence by most of the seed treatments as compared with the untreated checks Nos. 1 and 11, particularly in

TABLE 1.—*The effect of seed treatments for scab control upon the rate of emergence and stand in 1928 at 3 locations*

Treatment	Plot 1 Lincoln Irish Cobblers: Days after planting 34	38	41	Final stand	Plot 2 North Platte Irish Cobblers: Days after planting 26	30	35	Final stand	Plot 3 Alliance Bliss Triumphs: Days after planting 15	20	25	Final stand
	Per cent				*Per cent*				*Per cent*			
					HEALTHY SEED							
(1) No treatment	48	85	95	98	70	92	96	....	15	73	95	97
(2) Hot Formaldehyde 1:120	50	66	97	99	70	94	98	....	3	51	84	90
(3) Semesan Bel 1:20	42	82	95	100	78	94	96	....	11	75	95	97
(4) Hot Form. and Semesan Bel.	34	76	92	100	71	90	97	....	11	64	90	97
					SCABBY SEED							
(5) Hot Formaldehyde 1:120	31	77	87	96	60	81	88	....	1	30	63	77
(6) Mercuric Chloride 1:1000	26	72	82	94	65	90	94	....	2	29	47	57
(7) Semesan Bel 1:20	24	76	88	96	65	88	96	....	7	69	88	94
(8) Du Pont 76 B 1:40	32	76	85	98	66	99	99	....	1	45	83	95
(9) Bayer Dip Dust 1:20	26	59	....	85	73	93	95	....	7	53	81	93
(10) Bayer 190 1:20	34	81	90	99	73	95	97	....	9	71	93	97
(11) No treatment	48	83	91	97	78	96	98	....	13	58	86	91

Plot 1, Lincoln. The only treatment which did not retard emergence in Plot 1 was the hot formaldehyde treatment of healthy seed, altho the plants of the Semesan Bel treatment No. 3 and the Bayer 190 treatment No. 10 caught up very rapidly with the untreated checks. There was no great variation in final stand in Plot 1, except with Bayer Dip Dust, which was lowest.

This slow emergence and poor stand, which resulted in poor yields with the Bayer Dip Dust treatment, were caused by seed-piece injury. Planting was delayed at Lincoln for three or four days after treating due to wet weather and the cut seed pieces were kept under moist conditions to facilitate healing. After 36 hours it was noted that all the organic mercury treatments were causing a blackening of the cut surfaces where the freshly cut surface had come in contact with the treated surfaces. The seed pieces were therefore immediately spread out to dry and the injury was checked. The seed treated with Bayer Dip Dust was injured the most. Similar injury occurred in 1926 with Semesan Bel in the Lincoln and North Platte plots and in 1927 when cut seed was treated with Du Pont D. D. D. No. 2 at Lincoln and Semesan Bel at North Platte. The effect of this seed-piece injury was evident in both stand and yield.

In Plot 2, North Platte, there was slight retardation of emergence with four treatments, mercuric chloride, hot formaldehyde, and two organic mercury treatments of scabby seed. All of these eventually produced good stands except the hot formaldehyde treatment No. 5, altho the same treatment on healthy seed gave a 98 per cent stand without retardation of emergence.

In Plot 3, Alliance, there was considerable variation in the effect of treatments on emergence. Practically all treatments except Semesan Bel and Bayer 190 caused some delay in emergence. The only treatments affecting the final stand were hot formaldehyde and mercuric chloride.

These data do not exhibit any profound effect of the various seed treatments on stand altho, as noted above, most of the treatments slightly retarded emergence. While several of them resulted in poor stands, it should be noted that the same treatment often produced good stands in the other plots. Sometimes, even in the same plot, a treatment gave different results with healthy and scabby seed. The hot formaldehyde treatment of healthy potatoes caused no injury, while with scabby potatoes in the same stage of dormancy and treated in the same solution at the same time, it reduced the stand considerably.

In Table 1 the results do not indicate that scabby potatoes cause decreased stands. By comparing healthy and scabby potatoes untreated, Nos. 1 and 11, it can be seen that there was very little difference in either the rate of emergence or the final stand. In some of the tests, especially with Triumphs, seed potatoes that were so scabby as to render the finding of the eyes very difficult gave a perfect stand.

Effect on yield.—In order to conserve space and to present all the yield data on a comparable basis, the results are summarized as in Table 2. The actual yields with the probable errors are given only for the untreated scabby checks (Table 2, No. 21). The difference between the mean yield of each treatment and that of the untreated scabby check with the probable error of the difference is presented. In order to give some idea of the significance of the results, the ratio of the differences to the probable error of the difference is also given. The formula used for the calculations is given on page 12. The plus or the minus sign is used to indicate the increase or decrease in comparison with the check.

The data in Table 2 show that there was no consistent difference between the two untreated lots, Nos. 1 and 21, indicating that scab had no direct effect upon yield. If this conclusion is correct, then the control of scab by seed treatment would have no effect upon yield. There were, however, 55 instances of increased yields and 35 of de-

TABLE 2. *Effect of various seed treatments for scab control upon final yield.*

Treatment	ALLIANCE					
	1926		1927 [3]		1928	
	Difference [4]	Diff. / PE of Diff.	Difference [4]	Diff. / PE of Diff.	Difference [4]	Diff. / PE of Diff.
	Kilo		Kilo		Kilo	
HEALTHY						
(1) No treatment	+1.3±0.19	+6.7	+0.3±0.72	+0.4	+1.0±0.40	+2.4
(2) Hot Formaldehyde 1:120	......	......	+2.3±0.68	+3.5	+0.8±0.50	+1.7
(3) Mercuric Chloride 1:1000	+1.0±0.29	+3.3	......	......	......	......
(4) Semesan Bel 1:20	......	......	......	......	+3.0±0.42	+7.2
(5) Hot Formaldehyde and Semesan Bel	......	......	......	......	+0.8±0.88	+0.9
SCABBY						
(6) Hot Formaldehyde 1:120	+0.4±0.39	+1.1	+0.8±0.75	+1.0	+1.1±0.63	+1.7
(7) Mercuric Chloride 1:1000	—0.1±0.13	—1.0	—0.4±0.63	—0.6	—1.9±0.43	—4.4
(8) Mercuric Chloride Acidulated	......	......	......	......	+1.1±0.36	+3.0
(9) [1] Semesan Bel 1:10	+1.1±0.31	+3.6	+0.2±0.67	+0.3	+2.0±0.35	+5.5
(10) Semesan Bel Dust, 2 oz	+1.0±0.31	+3.1	......	......	......	......
(11) Du Pont D. D. D. 2 1:20	......	......	—0.2±0.62	—0.3	......	......
(12) Du Pont 12 Bel 1:10	+0.9±0.40	+2.2	......	......	......	......
(13) Du Pont 12 Bel Dust, 2 oz	+0.1±0.33	+0.4	......	......	......	......
(14) Du Pont 76 B 1:40	......	......	......	......	+1.6±0.42	+3.9
(15) Bayer Dip Dust 1:20	+0.9±0.36	+2.5	+1.1±0.71	+1.5	+0.4±0.34	+0.1
(16) Bayer 181 1:40	......	......	+1.9±0.66	+2.8	......	......
(17) Bayer 190 1:20	......	......	......	......	+2.0±0.31	+6.5
(18) Sulphur, 1 oz. per hill	+1.2±0.33	+3.6	—0.4±0.77	—0.5	......	......
(19) [2] Mercuric Chloride 2:1000	......	......	......	......	......	......
(20) [2] No treatment	......	......	+1.9±0.78	+2.4	......	......
MEAN YIELD OF 25-HILL UNITS OF UNTREATED SCABBY CHECKS						
(21) No treatment (scabby check)	4.0±0.13	......	12.3±0.57		7.35±0.24	

[1] Used at dilution of 1:20 in 1928.
[2] Slightly scabby seed was used (see page 9) for treatments Nos. 19 and 20.
[3] In 1927 all the organic mercury treatments, Nos. 9, 11, 15, and 16, were used on cut seed.
[4] All differences are based on the untreated scabby seed No. 21. Plus and minus indicate the increase or decrease for each treatment.

TABLE 2. *Effect of various seed treatments for scab control upon final yield. (Continued)*

Treatment	NORTH PLATTE					
	1926		1927 [3]		1928	
	Difference [4]	Diff. / PE of Diff.	Difference [4]	Diff. / PE of Diff.	Difference [4]	Diff. / PE of Diff.
	Kilo		Kilo		Kilo	
HEALTHY						
(1) No treatment	—1.3±1.50	—0.9	+0.7±0.87	+0.8	+0.5±0.38	+1.4
(2) Hot Formaldehyde 1:120	......	......	+0.1±0.87	+0.1	—0.4±0.62	—0.6
(3) Mercuric Chloride 1:1000	+0.2±1.3	+0.1	......	......	......	......
(4) Semesan Bel 1:20	......	......	......	......	—0.4±0.56	—0.6
(5) Hot Formaldehyde and Semesan Bel	......	......	......	......	—0.3±0.43	—0.6
SCABBY						
(6) Hot Formaldehyde 1:120	—1.5±1.26	—1.2	+0.7±1.40	+0.5	—0.7±0.61	—1.1
(7) Mercuric Chloride 1:1000	—1.1±1.41	—0.8	+3.2±1.26	+2.6	—1.7±0.63	—2.6
(8) Mercuric Chloride Acidulated	......	......	......	......	......	......
(9) [1] Semesan Bel 1:10	—0.9±1.07	—0.9	—4.4±0.96	—4.6	—0.3±0.89	—0.4
(10) Semesan Bel Dust, 2 oz	+0.3±1.47	+0.2	......	......	......	......
(11) Du Pont D. D. D. 2 1:20	......	......	—0.3±1.18	—0.2	......	......
(12) Du Pont 12 Bel 1:10	......	......	......	......	......	......
(13) Du Pont 12 Bel Dust, 2 oz	—0.5±1.35	—0.4	......	......	......	......
(14) Du Pont 76 B 1:40	......	......	......	......	+1.6±1.50	+1.1
(15) Bayer Dip Dust 1:20	......	......	+3.0±0.96	+3.1	+0.4±0.34	+1.1
(16) Bayer 181 1:40	......	......	+3.2±1.07	+3.0	......	......
(17) Bayer 190 1:20	......	......	......	......	—0.7±0.47	—1.5
(18) Sulphur, 1 oz. per hill	—1.0±1.28	—0.8	—1.5±0.91	—1.7	......	......
(19) [2] Mercuric Chloride 2:1000	—1.0±1.27	—0.8	......	......	......	......
(20) [2] No treatment	—0.4±1.3	—0.3	+3.2±1.15	+2.8	......	......
MEAN YIELD OF 25-HILL UNITS OF UNTREATED SCABBY CHECKS						
(21) No treatment (scabby check)	14.1±1.04		16.56±0.80		18.2±2.2	

[1] Used at dilution of 1:20 in 1928.
[2] Slightly scabby seed was used (see page 9) for treatments Nos. 19 and 20.
[3] In 1927 all the organic mercury treatments, Nos. 9, 11, 15, and 16, were used on cut seed.
[4] All differences are based on the untreated scabby seed No. 21. Plus and minus indicate the increase or decrease for each treatment.

TABLE 2. *Effect of various seed treatments for scab control upon final yield. (Concluded)*

Treatment	LINCOLN					
	1926		1927[3]		1928	
	Difference[4]	Diff. / PE of Diff.	Difference[4]	Diff. / PE of Diff.	Difference[4]	Diff. / PE of Diff.
	Kilo		Kilo		Kilo	
HEALTHY						
(1) No treatment	0.0±0.21	0.0	+0.4±0.43	+0.9	—0.1±0.47	—0.1
(2) Hot Formaldehyde 1:120	....	....	+8.3±0.40	+2.1	+0.7±0.71	+0.9
(3) Mercuric Chloride 1:1000	—0.3±0.28	—0.9	....	....	....	....
(4) Semesan Bel 1:20	....	....	....	....	+1.4±0.48	+3.0
(5) Hot Formaldehyde and Semesan Bel	....	....	....	....	+0.3±0.36	+0.8
SCABBY						
(6) Hot Formaldehyde 1:120	—0.4±0.23	—1.4	+0.2±0.45	+0.5	—0.2±0.42	—0.5
(7) Mercuric Chloride 1:1000	—0.01±0.35	—0.03	+0.7±0.51	+1.4	—0.5±0.68	—0.7
(8) Mercuric Chloride Acidulated	....	....	....	....	....	....
(9) [1] Semesan Bel 1:10	—0.2±0.21	—0.9	+0.8±0.66	+1.2	—0.6±0.46	—1.3
(10) Semesan Bel Dust, 2 oz	+0.1±0.28	+0.3	....	....	....	....
(11) Du Pont D. D. D. 2 1:20	....	....	—2.3±0.63	—3.7	....	....
(12) Du Pont 12 Bel 1:10	....	....	....	....	....	....
(13) Du Pont 12 Bel Dust, 2 oz	+0.4±0.22	+1.9	....	....	....	....
(14) Du Pont 76 B 1:40	....	....	....	....	—0.3±0.66	—0.4
(15) Bayer Dip Dust 1:20	....	....	+0.8±0.44	+1.8	—2.3±0.53	—4.3
(16) Bayer 181 1:40	....	....	+0.6±0.55	+1.1	....	....
(17) Bayer 190 1:20	....	....	....	....	+0.7±0.65	+1.0
(18) Sulphur, 1 oz. per hill	+0.3±0.28	+1.0	—1.0±0.51	—0.5	....	....
(19) [2] Mercuric Chloride 2:1000	+0.4±0.28	+1.35	....	....	....	....
(20) [2] No treatment	+0.5±0.18	+2.9	+1.6±0.41	+3.8	....	....
MEAN YIELD OF 25-HILL UNITS OF UNTREATED SCABBY CHECKS						
(21) No treatment (scabby check)	4.0±0.16		5.7±0.387		13.5±0.31	

[1] Used at dilution of 1:20 in 1928.
[2] Slightly scabby seed was used (see page 9) for treatments Nos. 19 and 20.
[3] In 1927 all the organic mercury treatments, Nos. 9, 11, 15, and 16, were used on cut seed.
[4] All differences are based on the untreated scabby seed No. 21. Plus and minus signs indicate the increase or decrease for each treatment.

creased yields in comparison with the scab check. It should be noted, however, that 5 of these decreases followed seed-piece injury as noted on page 13. While some of these differences might be considered mathematically significant, the authors believe that the use of an arbitrary standard such as 3 or 4 times the probably error, to determine significance, would in this case lead to false conclusions. It will be noted that none of the treatments gave consistent increases for the 3 years in all 3 plots, and that some of the greatest increases were accompanied by decreases in other years or in other plots for the same treatment. For example, mercuric chloride No. 7 gave an increase at North Platte in 1927 (page 16) as shown by the ratio of +2.6, but in 1928 there was a decrease with a ratio of –2.6 and the same year at Alliance (page 15) of –4.4.

The fact that there were more increases than decreases and that the increases were slightly larger indicates a tendency toward increased yields which may have been due to the control of Rhizoctonia, which possibly was present on the scabby seed. The only consistently increased yields occurred not with any one treatment in repeated tests but rather with all but one treatment in a single year, for example in 1926 and 1928 at Alliance (page 15). The chief difficulty in explaining these increases as being due to control of Rhizoctonia lies in the fact that the only treatment failing to show increase in these two years was mercuric chloride and this treatment, as will be shown later, is one of the most effective in controlling Rhizoctonia. The only conclusion that seems tenable to the authors after analyzing the data in Table 2 and considering all the factors involved in these tests, is that there is no significant difference in yields due to the control of scab by any of these treatments but that there is a slight tendency toward increased yields due to control of Rhizoctonia, which occurred in variable amounts on the seed tubers.

Effect on scab.—The effectiveness of the various treatments in controlling scab is presented separately for the three different plots in Tables 3, 4, and 5. As the data previously presented failed to show any appreciable differences in yield, these data are based on the percentage of commercial scab-free potatoes of U. S. Grade No. 1 size.

The results were obtained by sorting the potatoes into the three standard grade sizes and again into the various scab classes given on page 11. It would not be feasible to present this mass of detailed data in tabular form. An examination of the data showed that the method used in compiling the following tables is quite representative of the records. In order to illustrate this fact, the detailed data for the 1928 plot at Lincoln are presented in Fig. 1 as a typical example. The order of the treatments is based upon the percentage of Class 0 and 1 combined, as in Tables 3, 4, and 5. It can be seen from this figure that the relative effectiveness of the various treatments is much the same when based upon the combination of Classes 0 and 1 as when Class 0 is considered alone. There would be minor changes in the order of the treatments but it is clearly evident that with both methods the same treatments, 1 to 5, are the only ones showing satisfactory control and that the only treatment of scabby seed which falls in this group is the hot formaldehyde treatment No. 2. As previously noted, it was considered that the greatest error in making scab readings occurred with Class 0, due to the difficulty of detecting very small scab spots, and for this reason the combination of both classes is considered to be more accurate.

While there are some differences in the order if No. 2 size potatoes are considered, it is not great enough to alter the general results obtained if the total yield is considered. There is also very little difference in the percentage of No. 1 size potatoes produced with the various treatments. The only great difference in total yield occurred with Bayer Dip Dust No. 8 and in this case the decrease was due to seed-piece injury as previously noted.

From the commercial standpoint we are chiefly interested in the weight of No. 1 size scab-free potatoes produced, rather than the total weight or number of potatoes or the percentage of scab-free tubers of No. 2 size. For these various reasons, the authors feel that the method of presentation in Tables 3, 4, and 5 gives an accurate picture of the results.

A glance at Tables 3, 4, and 5 will show that most of the seed treatments failed to control scab effectively in all the tests. While some of the treatments apparently controlled scab to an appreciable extent in certain tests, the only consistent control in all three plots for the three years was obtained with the hot formaldehyde treatment. The amount of infection coming from the soil as evidenced by the amount of scab occurring with both untreated and treated healthy seed was especially great in the Alliance plot and as a result the effect of the hot formaldehyde treatment was not so evident, particularly in 1926 and 1928. (Table 5.)

The results with mercuric chloride explain why the growers of Nebraska had discontinued the use of this treatment.

	TREATMENT	AV. WT. PER HILL GRAMS	PER CENT OF TOTAL		
			NO. 1 SIZE	NO. 2 SIZE	NO. 3 SIZE
1	HEALTHY SEED - HOT FORMALDEHYDE + SEMESAN BEL	551.7	91.6	7.7	.6
2	SCABBY SEED HOT FORMALDEHYDE	533.4	91.3	8.0	.7
3	HEALTHY SEED SEMESAN BEL	595.3	92.9	6.0	1.0
4	HEALTHY SEED HOT FORMALDEHYDE	567.4	89.8	9.4	.8
5	HEALTHY SEED UNTREATED	536.6	92.0	7.0	.9
6	SCABBY SEED DU PONT 76 B	529.7	88.5	10.5	1.0
7	SCABBY SEED UNTREATED	541.4	89.2	9.0	1.4
8	SCABBY SEED BAYER DIP-DUST	450.8	91.6	6.9	1.5
9	SCABBY SEED SEMESAN BEL	517.5	89.8	9.7	.5
10	SCABBY SEED MERCURIC CHLORIDE	520.6	92.3	6.5	1.2
11	SCABBY SEED BAYER 181	575.2	91.9	7.2	.9

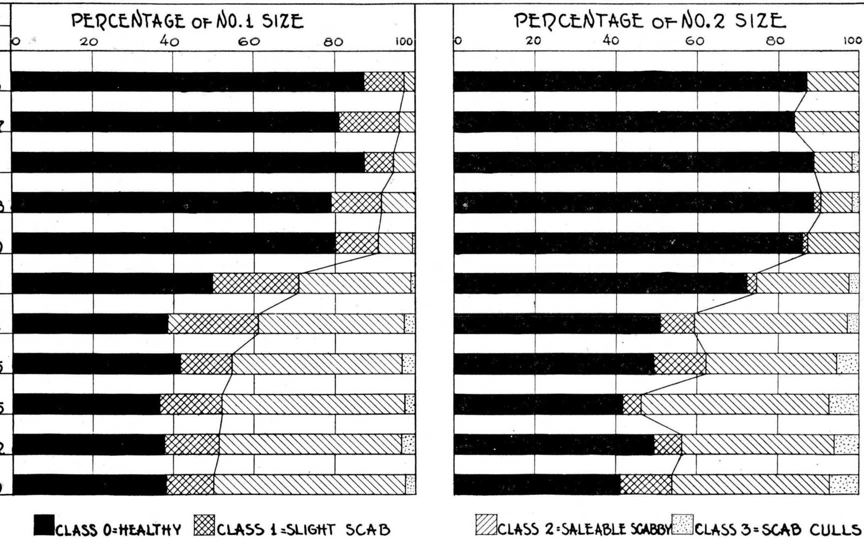

Fig. 1.—Results of seed treatments for scab control with Irish Cobbler potatoes at Lincoln, 1928

TABLE 3. *Percentage of scab-free Irish Cobblers with various seed treatments at Lincoln. Data based on weight of tubers of No. 1 size.*

Treatment	1926		1927 [3]		1928	
	Scab-free tubers	Diff. / PE of Diff.	Scab-free tubers	Diff. / PE of Diff.	Scab-free tubers	Diff. / PE of Diff.
	Per cent		*Per cent*		*Per cent*	
HEALTHY SEED						
(1) No treatment	53.6±4.20	+2.9 [4]	77.3±2.21	+11.3 [4]	90.8±1.11	+19.0 [4]
(2) Hot Formaldehyde 1:120	....	....	77.3±1.54	+12.9	91.9±1.86	+14.4
(3) Mercuric Chloride 1:1000	59.4±4.59	+3.7	....	....	....	....
(4) Semesan Bel 1:20	....	....	....	....	93.9±1.19	+15.4
(5) Hot Formaldehyde and Semesan Bel	....	....	....	....	97.5±0.63	+28.5
SCABBY SEED						
(6) Hot Formaldehyde 1:120	80.7±3.47	+8.8	92.1±1.01	+19.8	95.8±0.35	+29.7
(7) Mercuric Chloride 1:1000	27.0±2.93	—2.6	65.8±3.62	+ 5.8	52.1±2.89	— 2.7
(9) [1] Semesan Bel 1:10	34.6±4.64	—0.7	40.2±4.54	+ 0.06	50.0±5.68	— 1.8
(10) Semesan Bel Dust, 2 oz. per bu.	27.6±5.31	—1.8	....	....	....	....
(11) Du Pont D. D. D. 2, 1:20	....	....	52.8±3.82	+ 2.7	....	....
(13) Du Pont 12 Bel Dust, 2 oz. per bu.	20.4±2.59	—4.4	....	....	....	....
(14) Du Pont 76 B 1:40	....	....	....	....	70.1±2.08	+ 4.1
(15) Bayer Dip Dust 1:20	....	....	47.6±2.37	+ 2.2	55.1±3.18	— 1.6
(16) Bayer 181 1:40	....	....	51.9±2.65	+ 3.3	....	....
(17) Bayer 190 1:20	....	....	....	....	50.9±1.52	— 5.1
(18) Sulfur, 1 oz. per hill	30.2±4.11	—1.6	64.0±1.86	+ 7.7	....	....
(19) [2] Mercuric Chloride 1:1000	42.8±5.07	+0.7	....	....	....	....
(20) [2] No treatment	65.2±4.58	+4.8	65.5±2.89	+ 6.7	....	....
(21) No treatment	38.6±3.30	....	40.5±2.41	....	60.5±1.14	....

[1] Used at dilution of 1:20 in 1928.
[2] Slightly scabby seed was used (see page 9) for treatments Nos. 19 and 20.
[3] In 1927 the organic mercury treatments 9, 11, 15, and 16 were used on cut seed.
[4] All differences are based on the untreeated scabby seed No. 21. Plus and minus signs indicate the increase or decrease for each treatment.

TABLE 4. *Percentage of scab-free Irish Cobblers with various seed treatments at North Platte. Data based on weight of tubers of No. 1 size.*

Treatment	1926		1927 [3]		1928	
	Scab-free tubers	Diff. / PE of Diff.	Scab-free tubers	Diff. / PE of Diff.	Scab-free tubers	Diff. / PE of Diff.
	Per cent		*Per cent*		*Per cent*	
HEALTHY SEED						
(1) No treatment	85.2±3.12	+5.3 [4]	84.0±1.60	+ 9.1 [4]	95.3±0.50	+13.5 [4]
(2) Hot Formaldehyde 1:120	....	....	92.4±1.22	+12.8	92.4±0.39	+11.1
(3) Mercuric Chloride 1:1000	68.6±1.71	+2.9	....	....	....	....
(4) Semesan Bel 1:20	....	....	....	....	83.1±1.37	+ 0.5
(5) Hot Formaldehyde and Semesan Bel	....	....	....	....	91.3±1.23	+ 6.1
SCABBY SEED						
(6) Hot Formaldehyde 1:120	78.9±2.39	+5.1	85.7±3.78	+ 6.2	92.6±1.27	+ 6.8
(7) Mercuric Chloride 1:1000	47.0±3.86	—1.9	80.7±2.62	+ 6.7	69.5±1.45	— 7.7
(9) [1] Semesan Bel 1:10	46.6±3.75	—2.7	67.6±1.85	+ 3.2	74.2±2.46	— 3.1
(10) Semesan Bel Dust, 2 oz. per bu	43.1±1.82	—3.5	....	....	....	....
(11) DuPont D. D. D. 2, 1:20	....	....	60.8±2.49	+ 0.9	....	....
(13) Du Pont 12 Bel Dust, 2 oz. per bu	44.5±3.87	—2.4	....	....	....	....
(14) Du Pont 76 B 1:40	....	....	....	....	80.5±1.56	— 1.0
(15) Bayer Dip Dust 1:20	....	....	59.4±4.92	+ 0.3	68.3±2.97	— 4.5
(16) Bayer 181 1:40	....	....	62.5±1.72	+ 1.6	....	....
(17) Bayer 190 1:20	....	....	....	....	71.6±2.17	— 4.6
(18) Sulfur, 1 oz. per hill	58.2±2.62	+0.3	67.9±1.65	+ 3.5	....	....
(19) [2] Mercuric Chloride 1:1000	64.1±1.53	+1.8	....	....	....	....
(20) [2] No treatment	81.6±1.32	+6.4	74.7±4.79	+ 3.2	....	....
(21) No treatment	57.0±3.59	....	57.8±2.39	....	82.3±0.82	....

[1] Used at dilution of 1:20 in 1928.
[2] Slightly scabby seed was used (see page 9) for treatments Nos. 19 and 20.
[3] In 1927 the organic mercury treatments, 9, 11, 15 and 16 were used on cut seed.
[4] All differences are based on the untreated scabby seed No. 21. Plus and minus signs indicate the increase or decrease for each treatment.

TABLE 5. *Percentage of scab-free Triumphs with various seed treatments at Alliance. Data based on weight of tubers of No. 1 size.*

Treatment	1926		1927 [4]		1928	
	Scab-free tubers	Diff. / PE of Diff.	Scab-free tubers	Diff. / PE of Diff.	Scab-free tubers	Diff. / PE of Diff.
	Per cent		*Per cent*		*Per cent*	
HEALTHY SEED						
(1) No treatment	52.9±3.25	+4.8 [5]	55.3±3.72	+ 8.5 [5]	19.6±2.55	+2.6 [5]
(2) Hot Formaldehyde 1:120	....	....	82.1±2.37	+20.2	32.6±2.91	+6.3
(3) Mercuric Chloride 1:1000	35.0±4.70	+0.7	....	....	....	....
(4) Semesan Bel 1:20	....	....	....	....	22.5±2.66	+3.5
(5) Hot Formaldehyde and Semesan Bel	....	....	....	....	46.8±6.42	+5.3
SCABBY SEED						
(6) Hot Formaldehyde 1:120	53.6±7.15	+2.9	77.9±3.69	+13.9	17.0±3.59	+1.3
(7) Mercuric Chloride 1:1000	14.8±4.44	—3.05	27.8±2.59	+ 2.5	21.7±5.12	+1.8
(8) Mercuric Chloride Acidulated	....	....	....	....	18.4±3.10	+1.9
(9) [1] Semesan Bel 1:10	36.4±6.00	+0.8	29.2±3.90	+ 2.2	20.7±3.49	+2.3
(10) Semesan Bel Dust, 2 oz. per bu	37.4±6.88	+0.8	....	....	....	....
(11) Du Pont D. D. D. 2, 1:20	....	....	23.7±1.75	+ 2.1	....	....
(12) Du Pont 12 Bel 1:10	30.4±5.39	—0.1	....	....	....	....
(13) Du Pont 12 Bel Dust, 2 oz. per bu	34.5±5.64	+0.5	....	....	....	....
(14) Du Pont 76 B 1:40	....	....	....	....	17.8±3.73	+1.5
(15) [2] Bayer Dip Dust 1:20	27.5±4.49	—0.7	32.2±3.63	+ 1.8	23.6±2.81	+3.7
(16) Bayer 181 1:40	....	....	53.7±4.15	+ 7.4	....	....
(17) Bayer 190 1:20	....	....	....	....	11.1±3.69	—0.2
(18) Sulfur 1 oz. per hill	39.2±6.23	+1.2	34.0±3.30	+ 2.1	....	....
(20) [3] No treatment	....	....	49.0±5.12	+ 3.7	....	....
(21) No treatment	31.2±3.04	....	19.5±1.98	....	11.8±1.58	....

[1] Used at dilution of 1:20 in 1928.
[2] In 1926 used at strength of 1:30.
[3] Slightly scabby seed was used (see page 9) for treatment.
[4] In 1927 the organic mercury treatments, 9, 11, 15 and 16 were used on cut seed.
[5] All differences are based on the untreated scabby seed No. 21. Plus and minus signs indicate the increase or decrease for each treatment.

It was effective in only one out of the three years at Lincoln and North Platte and the increase of healthy tubers resulting from the treatment at Alliance in 1927 and 1929 was not enough to be considered very significant. The acidulated mercuric chloride tested in 1928 at Alliance also failed to control scab.

Likewise the various organic mercury compounds were lacking in effectiveness in the majority of the tests, and even in the few tests where they gave some signs of control the ratios were very slightly more than three times the probable error. In 1926 none of the organic mercury compounds tested gave any evidence of control. In 1927, Bayer 181 at Lincoln and Alliance and Semesan Bel Dip at North Platte gave a ratio of more than three times the probable error, but these ratios were only about one-half of those obtained with the hot formaldehyde treatment in the same plot. In 1928 the results were significant only in the case of Du Pont 76 B at Lincoln and none of these treatments was effective at North Platte. The results at Alliance in 1928 are of doubtful value with all treatments because of the amount of infection from the soil.

Sulfur failed to have any effect on scab in 1926, but in 1927 some control was evident in the Lincoln and North Platte plots. It failed to have any appreciable effect in either year at Alliance.

One interesting fact was the result obtained by using slightly scabby seed. Such seed, having only about three scab lesions per tuber, produced consistently more healthy potatoes than any of the treated scabby seed lots, except those treated with hot formaldehyde. It is probable that this seed did not cause enough infection to be evident in comparison with that coming from the soil. In other words, this seed gave about the same results as the healthy untreated lots, two of the tests having higher ratios than the healthy and three lower ratios. The mercuric chloride treatment of such seed did not produce measurable differences.

The healthy seed treated with hot formaldehyde produced a larger proportion of scab-free potatoes than the untreated healthy lots in four out of the six tests made, altho the difference was very slight in two of these cases. The greatest difference occurred at Alliance, where Bliss Triumph potatoes were used. These potatoes were from a lot of severely scabbed seed, and it was very difficult to select a sufficient amount of healthy seed. The color of this variety and the conditions under which they were selected very probably resulted in the presence of a certain amount of scab on the supposedly healthy seed, which would account for the increase in the percentage of scab-free tubers produced when such seed was treated with hot formaldehyde. In the Lincoln and North Platte tests, potatoes of the Irish Cobbler variety were selected in the laboratory. It was much easier to detect and discard potatoes with small scab spots on this white variety and as a result the treatment of this seed did not result in an increase in the percentage of healthy potatoes.

In general, the healthy, untreated seed produced a larger percentage of scab-free seed than the scabby seed treated with any of the treatments except hot formaldehyde.

We can conclude from the above data that: (1) the hot formaldehyde treatment resulted in the greatest and most consistent increase in the number of scab-free potatoes produced in comparison with the other treatments and the untreated checks; (2) scabby potatoes treated with hot formaldehyde were equal or superior to apparently healthy seed untreated; (3) the treatment of apparently healthy potatoes of the Bliss Triumph variety resulted in an increase in the percentage of scab-free potatoes; (4) none of the mercury treatments consistently decreased the amount of scab; and (5) with heavily infested soils and favorable conditions for scab, such as occurred in 1928 at Alliance, none of the treatments was beneficial.

RHIZOCTONIA EXPERIMENTS AT LINCOLN

Emergence and stand.—The rate of emergence and the final stands are presented in Table 6. In 1926 the most rapid emergence occurred with the healthy, untreated lot. The slowest emergence followed the hot formaldehyde treatment. All of the treatments either reduced the rate of emergence or failed to control completely the disease which, judging by the Rhizoctonia untreated check No. 16, materially reduced the rate of emergence. The final stands did not show any great variation; the hot formaldehyde and Semesan Bel treatments were the same as the untreated Rhizoctonia checks.

In 1927 there was no appreciable effect upon the rate of emergence except in the case of hot formaldehyde, Nos. 2 and 4, which retarded emergence. These two lots eventually caught up with the others and produced a good stand. The untreated Rhizoctonia lot emerged slowly and also produced the poorest stand. The stand resulting from the Bayer Dip Dust treatment No. 13 also showed considerable injury.

In 1928 the hot formaldehyde treatment did not cause any injury and its effectiveness was quite evident in re-

TABLE 6.—*The effect of seed treatments for Rhizoctonia control upon rate of emergence and stand of Early Ohio potatoes at Lincoln during 3 years*

Treatment[1]	Percentage of plants emerging and final stand											
	1926				1927				1928			
	Days after planting			Final stand	Days after planting			Final stand	Days after planting			Final stand
	32	36	39		30	33	44		34	38	41	
	Per cent				*Per cent*				*Per cent*			
HEALTHY SEED												
(1) No treatment	11	34	79	99	12	63	94	97	7	74	83	95
(2) Hot Formaldehyde 1:120	....	....	....	....	9	45	97	97	3	59	88	99
(3) Mercuric Chloride 1:1000	6	25	72	99	....	....	....	....	....	....	....	....
RHIZOCTONIA SEED												
(4) Hot Formaldehyde 1:120	1	6	39	95	8	55	97	99	11	67	85	95
(5) Mercuric Chloride 1:1000, 1½ hrs.	7	19	66	98	13	56	95	98	2	56	91	99
(6) Mercuric Chloride 1:1000, presprinkled	7	23	69	98	12	71	95	98	....	....	....	....
(7) Du Pont 12 dust, 2 oz. per bu.	3	21	52	99	....	....	....	....	....	....	....	....
(8) Du Pont 12 dust, presprinkled	9	24	59	98	....	....	....	....	....	....	....	....
(9) Semesan Bel dust, 2 oz. per bu.	5	15	54	95	....	....	....	....	....	....	....	....
(10)[2] Semesan Bel 1:10	8	29	64	96	19	60	90	95	2	53	85	98
(11) Du Pont D. D. D. 2 1:20	....	....	....	....	13	65	93	87	....	....	....	....
(12) Du Pont 76 B 1:40	....	....	....	....	....	....	....	....	1	40	73	92
(13) Bayer Dip Dust 1:20	....	....	....	....	12	64	90	90	1	45	83	99
(14) Bayer 190 1:20	....	....	....	....	....	....	....	....	1	45	74	92
(15) Bayer 181 1:40	....	....	....	....	13	61	87	99	....	....	....	....
(16) No treatment	4	18	40	95	10	46	80	82	2	57	84	99

[1] The mercury treatments 6 and 8 in 1926 and 10, 11, 13, and 15 in 1927 were made on tubers cut 18 to 24 hours before treating.
[2] Used at dilution of 1:20 in 1928.

ducing the damage due to the disease, as indicated by the rate of emergence in comparison with all the other treatments and the untreated Rhizoctonia lot. The disease did not, however, exert any effect on the final stand. All of the stands were very good with the possible exception of the two mercury compounds, Du Pont 76 B and Bayer 190.

The general tendency of all treatments was to reduce the rate of emergence in comparison with the healthy, untreated check. Hot formaldehyde caused injury as indicated by retarded emergence in two of the three years but was very satisfactory in 1928. There was little difference in the final stands with any of the treatments. In only one year, 1927, did the disease affect the stand to any marked extent.

Stem lesions.—In 1928 four additional 25-hill rows were used for each test for the purpose of digging at stated intervals and examining for the number and severity of Rhizoctonia lesions on the stems. The *plot was planted*

TABLE 7.—*The effect of seed treatments for Rhizoctonia control upon the number and severity of stem lesions. Early Ohio potatoes at Lincoln, planted April 8, 1928*

Treatment [1]	Stems examined								
	June 5			June 13			June 28		
		Infected			Infected			Infected	
	Total No.	Per cent	Severity [2]	Total No.	Per cent	Severity [2]	Total No.	Per cent	Severity [2]
				HEALTHY SEED					
(1) Untreated	37	32.4	2	50	24.0	1	109	64.5	3
(2) Hot Formaldehyde 1:120	62	33.9	1	61	47.4	1	114	68.4	3
				RHIZOCTONIA SEED					
(4) Hot Formaldehyde 1:120	38	23.7	1 [3]	53	35.9	1	110	44.4	2
(5) Mercuric Chloride 1:1$$$	48	54.2	1 [3]	49	38.8	2	89	65.2	3
(10) Semesan Bel 1:20	51	66.7	5	52	61.5	5	90	64.5	4
(12) Du Pont 76 B 1:40	42	33.3	2	39	46.2	2	99	37.3	2
(13) Bayer Dip Dust 1:20	59	62.6	3	45	62.2	3	103	54.4	3
(14) Bayer 190 1:20	52	51.9	3	49	73.5	3	105	62.8	4
(16) Untreated	58	53.4	4	56	46.4	2	111	64.9	5

[1] One-half of the seed tubers in each lot were treated whole and one-half after cutting. As no differences were apparent the results for both cut and whole seed are combined.
[2] Slight infection is indicated by 1, severe infection by 5.
[3] These 2 lots had no severe lesions.

April 8 and the first set of 25 hills was dug on June 5, the second set on June 13, and on June 28 two sets of 25 hills each were dug and examined. All hills were handled separately and the stems were thoroly washed before being examined.

The data presented in Table 7 are based upon the number and severity of the lesions per stem. This was found to be a more accurate basis than the infection per hill. The slight infection referred to in the table means a few small surface lesions. The most severe types occurred as deep lesions girdling the stems or killing the growing point of the sprout. Judging from the amount of infection that occurred with the healthy seed, both treated and untreated, there was considerable infection from the soil. Slightly more than 30 per cent of the stems from healthy seed were infected at the time of the first digging and the amount increased during the season, as 64 per cent of the stems from healthy seed were infected on June 28. Such extensive infection from the soil naturally resulted in considerable variation so that it is difficult to determine, from the percentage of healthy stems, the relative effectiveness of the various treatments; however, the severity of infection differed greatly so that certain consistent differences can be noted when the amount and severity of infection are considered together as in Table 7. The healthy seed, both untreated and treated with hot formaldehyde, and the Rhizoctonia seed treated with hot formaldehyde, mercuric chloride, or Du Pont 76 B, were consistently the healthiest, the mercuric chloride treatment being the poorest of these five lots. At the time of the third digging, June 28, the amount of soil infection was so great that the differences between the different treatments were not so evident. The other three organic mercury treatments, Semesan Bel, Bayer Dip Dust, and Bayer 190 were infected about the same as the untreated Rhizoctonia check.

Sclerotia on tubers.—Under average conditions, the chief injury caused by Rhizoctonia in the eastern section of Nebraska, as represented by the Lincoln plot, is due to the effect upon stand and yield caused by infection of the underground stem. The production of sclerotia on the new tubers is usually not important, but this type of infection is often used to gauge the effect of seed treatments. A record was therefore made of the severity of infection on the tubers in 1926 and the results are presented in Table 8. All the tubers were washed at digging time and graded as of slight, medium, or severe infection, depending upon the number and size of sclerotia. Practically all sclerotia

TABLE 8.—*The effect of seed treatments as judged by the formation of sclerotia on the tubers in 1926 at Lincoln*

Treatment	Average yield per hill	Percentage of total yield			
		Healthy	Slight infection	Medium infection	Severe infection
	Grams	*Per cent*	*Per cent*	*Per cent*	*Per cent*
HEALTHY SEED					
(1) Untreated	193	66.5	29.1	4.1	.3
(3) Mercuric Chloride 1:1000	210	78.2	20.6	1.2	.0
RHIZOCTONIA SEED					
(4) Hot Formaldehyde 1:120	160	61.5	30.1	8.3	.0
(5) Mercuric Chloride 1:1000	181	64.5	31.8	3.8	.0
(6) Mercuric Chloride 1:1000, presprinkled	208	69.7	29.4	.9	.0
(7) Du Pont 12 Bel Dust, 2 oz. per bu.	192	33.1	31.4	32.2	3.z
(8)[1] Du Pont 12 Bel Dust, presprinkled	185	46.7	29.1	20.8	3.4
(9) Semesan Bel Dust, 2 oz. per bu.	202	37.1	33.1	24.9	4.9
(10) Semesan Bel Dip 1:10	206	40.3	42.5	15.4	1.7
(16) Untreated	155	16.1	58.6	20.1	5.1

[1] Seed tubers cut before treating. All other treatments were made on uncut tubers.

were of the small type, averaging about 1/8 of an inch in size. Severe infection refers to tubers having such sclerotia abundantly scattered over the entire surface of the tuber. It is evident from treatment Nos. 1 and 3 wih healthy seed that there was considerable infection originating in the soil. Nevertheless, there is a marked difference between the small percentage of healthy tubers produced by the untreated Rhizoctonia check No. 16 and all of the treated lots. The mercuric chloride with a presprinkle produced the largest percentage of healthy tubers of any of the treatments with infected seed. The mercuric chloride without presprinkle and the hot formaldehyde treatments were also very satisfactory. The organic mercury compounds were better than the untreated checks but were far below the mercuric chloride and hot formaldehyde in effectiveness. This is even more noticeable if the severity of infection is considered, as shown in the last two columns of Table 8. The hot formaldehyde produced the lowest yield due to retarded emergence, as previously mentioned in connection with Table 6. The percentage of healthy tubers was so high, however, that the actual weight of healthy potatoes produced was greater than with the uninjured, higher-yielding, organic mercury compounds with their low percentages of healthy tubers.

On the basis of the formation of sclerotia on the new tubers, mercuric chloride was the best treatment and hot formaldehyde was a close second.

Effect upon yield.—From the standpoint of practical results, the effect of Rhizoctonia and the various treatments tested to control it can best be judged by the yield of potatoes. For this reason the yield was made the chief consideration in these tests. The data previously discussed and presented in Tables 6, 7, and 8 are then important only as a means of explaining the effects upon the yield.

The data on yield are presented for the three years in Table 9. The actual yield for the untreated Rhizoctonia check, No. 16, and also the increase or decrease following the various treatments, based upon the untreated Rhizoctonia check with the probable error and the ratio, are given. In 1926 all the treatments showed an increase in yield. While the increase with the hot formaldehyde was the smallest, it was the most uniform in all the replications of any of the treatments with Rhizoctonia seed. This small increase was probably due to retarded emergence, as noted in Table 6. The final stand was uninjured, but the late emergence, combined with a period of very hot, dry weather which killed all the plants several weeks before maturity, as indi-

TABLE 9. *The effect of seed treatments for Rhizoctonia control upon the total yield of Early Ohio potatoes at Lincoln—during 3 years, 1926-8.*

	Treatment[1]	1926 Difference[3]	1926 Diff. / PE of Diff.	1927 Difference[3]	1927 Diff. / PE of Diff.	1928 Difference[3]	1928 Diff. / PE of Diff.
	HEALTHY SEED						
(1)	No treatment	+1.86±0.26	+7.2	+2.84±0.69	+4.1	—1.1±0.85	—1.3
(2)	Hot Formaldehyde 1:120	....	....	+2.14±1.05	+2.0	+0.2±1.00	+0.2
(3)	Mercuric Chloride 1:1000	+2.25±0.17	+13.2	....	....	....	....
	RHIZOCTONIA SEED						
(4)	Hot Formaldehyde 1:120	+0.92±0.25	+3.7	+4.39±1.08	+4.1	—0.4±1.09	—0.4
(5)	Mercuric Chloride 1:1000	+1.79±0.42	+4.3	+5.64±0.71	+7.9	+5.4±0.95	+5.7
(6)	Mer. Chloride 1:1000, presprinkled	+1.18±0.67	+1.8	+3.45±1.03	+3.3	....	....
(7)	Du Pont 12 dust, 2 oz. per bu	+1.52±0.27	+5.6	....	....	....	....
(8)	Du Pont 12 dust, presprinkled	+1.04±0.54	+1.9	....	....	....	....
(9)	Semesan Bel dust, 2 oz. per bu	+1.88±0.26	+7.2	....	....	....	....
(10)[2]	Semesan Bel Dip 1:10	+1.36±0.68	+2.0	+1.70±0.89	+1.9	+2.4±1.14	+2.1
(11)	Du Pont D. D. D. 2 1:20	....	....	+2.54±0.89	+2.9	....	....
(12)	Du Pont 76 B 1:40	....	....	....	....	+1.9±0.89	+2.1
(13)	Bayer Dip Dust 1:20	....	....	+0.34±1.20	+0.3	+2.4±0.74	+3.2
(14)	Bayer 190 1:20	....	....	....	....	+3.4±1.01	+3.4
(15)	Bayer 181 1:40	....	....	+3.50±0.89	+3.9	....	....
	MEAN YIELD OF 25-HILL UNITS OF UNTREATED RHIZOCTONIA CHECKS						
		Mean ± PE		Mean ± PE		Mean ± PE	
(16)	No treatment (Rhizoctonia check)	7.76±0.11		12.63±0.54		+25.5±0.61	

[1] The organic mercury treatments Nos. 6 and 8 in 1926 and 10, 11, 13, and 15 in 1927 were made on tubers cut 18 to 24 hours before treating.

[2] Used at dilution fo 1:20 in 1928.

[3] All differences are based on the untreated Rhizoctonia seed No. 16. Plus and minus signs indicate the increase or decrease for each treatment.

cated by the low yield of the checks, resulted in a very small but uniform increase for the hot formaldehyde treatment.

In 1927 all of the treatments again resulted in increased yields. The hot formaldehyde treatment again retarded emergence as shown in Table 6, but, apparently because of more favorable weather conditions later in the season as compared with 1926, the plants were enabled to overcome the delayed emergence and the yield was materially increased. The low yield with Bayer Dip Dust was probably due to the seed-piece injury previously noted, which reduced the final stand (Table 6).

The results obtained in 1928 are more difficult to interpret. The effect of the various treatments was much less than in the two previous years. The hot formaldehyde for the first time did not retard emergence as shown in Table 6 and, judging by the amount of stem infection (Table 7), it controlled the disease better than any other treatment; and yet the yield (Table 9) was slightly less than the check. Mercuric chloride, which did not reduce the amount of stem infection as much as did hot formaldehyde, resulted in the highest yield. Bayer 190, which gave the next highest yield, showed very poor control as judged by the amount of stem infection. The lack of any increase in the yield of the untreated lots of healthy over the untreated Rhizoctonia seed is evidence that the disease as carried by the seed was not much of a factor in determining the yield. It was undoubtedly a factor in the number of stem lesions found at the time of the first two samplings (Table 7) but, as shown in the same table, the amount of infection from the soil was so great by the time of the last sampling that there was very little difference in the treatments. This large amount of infection from the soil, which may have resulted in injury to the stolons, combined with hot, dry weather during the later part of the growing season, probably was the cause of the inconclusive results in 1928, as based upon yields, presented in Table 9.

Considering all the data presented in Tables 6, 7, 8, and 9, the following conclusions can be drawn. The hot formaldehyde and the mercuric chloride treatments were quite effective in controlling the disease, altho the hot formaldehyde retarded emergence in two of the three years. Even with this retarded emergence, the yield was materially increased over the untreated Rhizoctonia seed. The organic mercury compounds reduced the amount of infection on stems and tubers and increased the yield, but not so much as the mercuric chloride treatment. The presprinkle method did not show any advantage. The disease was found to decrease the stand materially in only one of the three years. The amount of stem infection, however, resulted in reduced yields. When infection from the soil was severe, as in 1928, it was sufficient to obscure the effects of seed treatment.

RELATION OF SEED TREATMENTS TO SEED-PIECE DECAY AND PLANT VIGOR

The question of seed-piece preservation and stimulation of growth was not considered as part of the original project, but in view of various reports which have been made, indicating that certain seed treatments stimulated growth and increased yields, a few additional tests were included. Quite often reports of experiments conducted for scab control are presented on the basis of yields, even tho there is practically no evidence indicating that the scab disease has any appreciable depressing effect upon yields. The experiments on scab reported in this paper have failed to disclose any consistent tendency for the scab disease to decrease yields or for any of the seed treatments to increase yields (Table 2). In the Rhizoctonia tests the effect of the disease upon yield is quite evident and the possible effect of seed treatments in stimulating growth cannot be separated from the effects caused by disease control in such experiments. Tests of the effect of seed treatments on growth stimulation with cereal crops at this station, as reported by Kiesselbach (7), have been entirely negative. It was thought possible, however, in the light of Denny's (3) work on seed-piece preservation and decay that certain seed treatments might have a favorable effect upon the growth of the potato.

In 1928 an additional test was inserted in all three plots used for the scab tests. In addition to the healthy untreated check and the healthy lot treated with hot formaldehyde, two additional lots of healthy seed were planted. One of these was treated with Semesan Bel and the other with hot formaldehyde first and then Semesan Bel. It was thought that with these four lots of healthy seed it would be possible to obtain any evidence of increased yield due to the organic mercury treatment exclusive of disease control. The results are included in the data presented in Table 2 on yield, and in Tables 3, 4, and 5 on scab control.

In the Lincoln test the healthy seed treated with Semesan Bel was the highest-yielding lot in the experiment. The Semesan Bel, used after hot formaldehyde, produced slightly less than the hot formaldehyde alone, both being higher than the healthy, untreated check. In the North

Platte tests the reverse was true; all three lots of treated healthy seed produced about the same and all of them less than the untreated check. The results at Alliance were similar to those at Lincoln with even a greater increased yield for the healthy seed treated with Semesan Bel. Again the double treatment with hot formaldehyde and Semesan Bel was slightly less than that of the hot formaldehyde alone. It is also noticeable in Table 2 that in the Alliance plots two organic mercury scabby-seed treatments, Semes-Bel and Bayer 190, gave the largest increases in yield in 1928. They failed to show any significant increase in the Lincoln and North Platte plots, however.

In addition to the data mentioned above, some information was obtained in the 1928 test at Alliance on seed-piece decay and plant vigor. On July 26, two 25-hill replications of each treatment were dug. The condition of the seed pieces was noted and the green weight of the tops determined. These data are presented in Table 10 along with the stand percentages and the actual yield of the other six replications for each treatment upon which are based the ratios presented in Table 2.

The greatest amount of seed-piece rot occurred with the scabby seed untreated. This may not be very significant, however, as all but two treatments resulted in the complete rotting of 70 per cent or more of the seed pieces. Scabby seed treated with mercuric chloride and scabby seed with Du Pont 76 B showed the least amount of rot. Scabby seed treated with Semesan Bel also resulted in a large percentage of sound seed pieces.

There was no close correlation between the amount of seed-piece rotting and the vigor of the plants as indicated by the green weight of the tops. Neither was there any correlation between either seed-piece rot or vigor and the total yield of the other replications with similar treatments.

When the green weight of the tops was calculated per plant according to the condition of the seed piece, there was very little uniformity in the results. If anything, the vine growth seemed to be greater when the greatest amount of rotting occurred, but this was not consistent.

The results presented do not show any correlation between seed-piece rot and vigor of the vines or yield. Neither did the organic mercury compounds as a whole appear to prevent decay of the seed pieces.

DISCUSSION OF RESULTS

Consideration of seed and soil infection.—The disinfection of seed potatoes to prevent scab and Rhizoctonia is a long-established practice. Many investigators have re-

TABLE 10.—*Relation of seed treatments to seed-piece decay and vigor of plants. Alliance, 1928*

Treatment	Two replications of 50 hills each, dug 42 days after planting										Actual yield of 6 other replications per 25 hills
	Stand	Condition of seed pieces as percentage of seed planted [1]				Green weight of tops per plant July 26	Average weight of green tops per plant on basis of condition of seed piece				
		Complete rot	More than ½ rot	Less than ½ rot	Sound		Complete rot	More than ½ rot	Less than ½ rot	Sound	
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Kilo.*
HEALTHY [redacted] SEED											
(1) No treatment	91	87	3	5	5	290	282	170	375	395	8.30
(2) Hot Formaldehyde 1:120	88	86	2	8	4	387	402	520	316	172	8.20
(3) Semesan Bel 1:20	94	78	6	6	10	339	349	305	350	340	10.38
(4) Hot Form. and Semesan Bel	100	86	2	2	10	378	380	565	25	314	8.13
SCABBY [redacted] SEED											
(5) Hot Formaldehyde 1:120	82	76	6	6	12	174	194	233	131	69	8.42
(6) Mercuric Chloride 1:1000	82	48	6	22	24	287	272	263	76	241	5.49
(7) Semesan Bel 1:20	100	70	6	2	22	356	373	426	200	295	9.31
(8) Du Pont 76 B 1:40	98	46	4	22	28	336	385	345	324	243	9.00
(9) Bayer Dip Dust 1:20	98	84	4	6	6	394	398	425	287	168	7.40
(10) Bayer 190 1:20	92	88	8	0	4	372	388	212	0	185	9.38
(11) Mercuric Chloride Acidulated	98	80	2	4	14	329	327	230	307	355	8.43
(12) No treatment	95	97	1	0	2	321	314	430	0	550	7.35

[1] These figures include missing hills due to rotted seed pieces but the green weights are based on actual stand.

ported beneficial results from various treatments and have recommended their use. Recently, however, Clayton (2) has questioned the advisability of using seed-potato treatments under conditions where relatively scab-free seed can be used and where the soil is heavily infested. He concludes from his experiments conducted on Long Island that "Regardless of the amount of scab infection on the tubers, if these were planted in the normally acid soils used for potato growing on Long Island, the crop was practically clean, while if planted on land that had been limed, the crop was heavily scabbed, the main source of infection being the soil. The treatment of the seed reduced the percentage of infection, but hardly enough to justify the bother."

Likewise, Vaughn (14) states regarding tests in Wisconsin that "The limited tests with organic mercury at the Spooner farm showed no value over the untreated seed in Triumph variety where a slight scab infection was present in the soil."

While it may be interesting and worth while to determine that various seed treatments do control, at least partially, the scab borne on the seed, the point made by Clayton is well taken, that if such treatments do not return an adequate profit it is useless to employ them. It is certainly essential to determine the efficacy of the treatment as a practical control measure, and in deciding this the amount of soil infection becomes of prime importance.

The conditions of the experiments reported in this bulletin varied considerably as to soil infection. With high pH values and with the predominant soil type in the large commercial area being a fine sandy loam, as represented by the Alliance plot, it is apparent that conditions are favorable for scab and that the amount of scab will vary according to climatic conditions and the amount of infestation in the soil. While these areas have not been cropped to potatoes for many years, this factor is apparently not important under Nebraska conditions, as the writers have often observed practically 100 per cent infection from the soil on land never before cropped to potatoes.

With this amount of infection occurring from the soil, it becomes difficult for the growers in some sections to obtain scab-free seed potatoes, especially in view of the fact that the most severe soil infection occurs in some of the areas considered most satisfactory for seed production. As a general practice, we may assume that with a large amount of scab produced in any one year we will have a proportionately large amount of scabby seed planted the next year. This is particularly true when good-quality certified seed has to be culled out solely on account of scab. The effective treatment of such scabby seed becomes of great financial interest to the grower. In eastern and central Nebraska the seed potatoes are usually imported from the North and usually carry a heavy infection of Rhizoctonia. It can therefore be seen that even tho the soil is heavily infested, as has been shown in the tables, the probability that the seed is infected makes a profitable return from seed treatment a greater likelihood than in sections where scab-free potatoes are always available. It is true that under conditions of heavy soil infection, as have occurred at Alliance, especially in 1928, the value of the treatment is greatly reduced. Nevertheless, the consistent increase in the percentage of healthy potatoes resulting from seed treatment shows that even with this smaller margin it may still be profitable to treat such scabby seed. It must also be remembered that in a number of other sections of western Nebraska the amount of soil infection is not so great as is indicated in the results from this plot, which in all three years happened to be on heavily infested soil.

Effect of seed treatments on scab.—Of the different treatments used, the results show that the most consistent control was obtained by the hot formaldehyde treatment. The mercury compounds, including mercuric chloride, failed to decrease the amount of scab appreciably in most of the tests. These results are quite the opposite of those published by various workers. For example, Martin (8) in New Jersey has reported consistent results over a period of years showing the effectiveness of the organic mercury compounds in controlling scab and he recommends their use as a practical control measure. He found that the organic mercury compounds were more effective than the standard mercuric chloride treatment, while in the tests reported herein they were about equally ineffective. It is difficult to arrive at any theory that will satisfactorily explain the differences in these results. The experiments reported here were planned and carried out in much the same way as were those reported by Martin. The differences in soil infestation can hardly account for the results when checks and treated lots are systematically replicated as they were in these experiments. The materials used for the treatments were similar except for the water used in making the solutions. While the water used in these experiments, particularly at Alliance, was strongly alkaline, tests failed to reveal any precipitation of mercury in the mercuric chloride solutions. If the hot formaldehyde treatment had been included in the experiments reported from New Jersey, it is possible that a better comparison of the results obtained with the mercury treatments could have been made with the results here presented. The only conclusion to be drawn at the present time is that, as the authors have previously stated (5), "The necessity for determining locally the relative efficacy of various treatments is clearly apparent, and a treatment which has been found to be effective in one section of the country is not necessarily going to yield similar results in other sections." Certainly more detailed experimental work is necessary before the factors causing these marked differences in results can be determined.

Another surprising result obtained in these investigations was the lack of control obtained with the mercuric chloride treatment. This treatment has been reported by many workers as satisfactory in controlling scab and for years was considered the standard treatment. For scab control it has been displaced in most sections by the hot formaldehyde or organic mercury treatments, not because of any great difference in control but rather because of the disadvantages of the slow, time-consuming nature of the treatment. The results reported in this bulletin are in general accord with the results obtained by potato growers, who have largely abandoned this method.

Contrary to the statement previously made by the authors (4) which was based upon the 1927 results, it now appears from a summary of the three years' work that the only significant difference between the treated and untreated healthy seed occurred at Alliance with the Bliss Triumph variety. The difficulty of detecting small scab spots on this as contrasted with the Cobbler variety used in the other tests probably accounts for the difference. It must be remembered, however, that the healthy seed selected for these experiments would be much better than seed ordinarily considered healthy on the farm. A large percentage of the seed used in commercial plantings is infected with scab, the amount varying in the different sections, so that the treatment of such apparently healthy seed on the farm, particularly of the Bliss Triumph variety, would probably result in a decrease in the amount of scab that would more than repay the cost of the treatment.

Effect of seed treatments on Rhizoctonia.—Considerable conflicting data regarding the control of Rhizoctonia have been presented by various workers. White (15), in summarizing experiments reported from various states and

Canada in 1926, concludes that "In general, although by no means consistently so, the Semesan Bel compounds used as a 10 per cent dip have given satisfactory control of stem lesions, have resulted in at least 20 per cent increases in yield and have yielded a crop as free of sclerotia as the standard corrosive sublimate treatment."

Raeder, Hungerford, and Chapman (12) reported that the organic mercury compound, Du Pont Dust No. 15, gave better control than any other treatment tested. Further tests by Raeder and Hungerford (13) showed that the results with this and other organic mercurials were not consistent. Hungerford (6), in discussing the results of these seed-treatment experiments in Idaho, states that "the hot formaldehyde method of treatment has been recommended because it has given year after year the best control of both Rhizoctonia and scab."

Clayton (2) states that "the organic mercurials controlled seed-borne scab infection about as well as mercuric chloride but were less effective against black scurf." Miles (10), summarizing experiments conducted in Washington, states that in no instance was there any effective control of Rhizoctonia as measured by sclerotia on the tubers at harvest with either Semesan Bel or Bayer Dip Dust, while mercuric chloride gave some measure of control in every test except where heavy soil infection occurred. Moore and Wheeler (11), from tests conducted in Michigan, also conclude that mercuric chloride is more effective in the control of Rhizoctonia than the organic mercurials.

In reviewing these and other papers, it is clearly evident that the tendency of the recent work is to consider the organic mercury compounds as less effective against Rhizoctonia than against scab.

The results presented in this paper, however, are directly opposed to this view, as the organic mercury compounds and the mercuric chloride treatment were more effective against Rhizoctonia than against scab. Increased yields were consistently obtained with all the mercury treatments. A decreased number of infected tubers was produced, altho here the results were better with hot formaldehyde and mercuric chloride than with the organic mercurials. On the basis of stem lesions, the hot formaldehyde was the best treatment. In the final analysis, the practical usefulness of these treatments in the early table-stock potato-producing area of Nebraska must depend upon increased yields. On this basis the mercuric chloride treatment gave the most consistently satisfactory results. Hot formaldehyde, while controlling the disease more effectively than any other treatment, retarded emergence in two of the three years and when this was combined with unfavorable weather, as in 1926, the beneficial results obtained by disease control were somewhat reduced. General practice has proved that the hot formaldehyde method, if carefully used, results in increased yields thruout eastern Nebraska, due to the control of Rhizoctonia. The retarding of emergence due to hot formaldehyde treatment[1] can be eliminated by treating the potatoes several weeks or months ahead of planting time or before the sprouts have developed. When proper precautions are taken to allow the potatoes to dry off properly after treating, there should be no undesirable results.

The variation in the results obtained by different workers may be due not only to different criteria of control, depending upon whether the potatoes are being produced for seed or table stock use, but also to the type of sclerotia present on the seed tubers. This latter fact is probably responsible for the difference between these results for the presprinkle method of treatment and those reported by Raeder, Hungerford, and Chapman (12). In these experiments the sclerotia were small and presprinkling was evidently not necessary.

The 1928 results also showed conclusively that when a heavy infection from the soil occurs, the beneficial effect of the treatment is reduced to a minimum or may not be at all evident. As the seed planted in eastern Nebraska is rather generally infected with Rhizoctonia, the use of a seed treatment in most years returns a very satisfactory profit.

Effect of seed treatments on yields.—In regard to increased yields obtained by the use of the organic mercury treatments other than thru the control of Rhizoctonia, the evidence presented is largely negative. Certain workers have reported increases due to organic mercury treatments that are not correlated with disease. Most of these claims have been made by workers in Europe. In the United States very few experiments on this point have been made. Clayton (2) states that in his experiments, "The organic mercury treated seed has outyielded the mercuric chloride treated and the untreated seed. These differences have not been attributable to disease control, since, in this respect, the mercuric chloride was superior." Brann and

[1] Since the preparation of this manuscript, a recent publication (White, R. P., Potato Experiments for the Control of Rhizoctonia, Scab and Blackleg, 1922 to 1927. Kans. Agr. Expt. Sta. Tech. Bul. 24, 37 pages, 1928) has been received. White notes similar injury caused by hot formaldehyde and refers to it as "induced dormancy" resulting in delayed emergence. To overcome this, he recommends fall or early spring treating at least one month before planting.

Vaughn (1), in a report from Wisconsin in which the detailed experiments are not recorded, state that the organic mercury compounds resulted in slightly higher yields. They recommend that when scab or Rhizoctonia are prevalent the mercuric chloride method should be used, and when these diseases are not serious the organic mercury treatments will give beneficial results.

In the experiments reported in this bulletin there was little evidence that scab had any effect upon yield. Differences in yield due to the treatments rather than disease control might therefore be expected to show definite results. The data presented in Table 2, however, do not show any significant and consistent increase in yields from the organic mercury treatments. The only outstanding increase obtained from these treatments was in 1928 at Alliance, and this was the only time the plants of these treatments were perceptibly greater in size than those of the other treatments. The results for the nine tests certainly do not indicate that the use of these treatments for the purpose of increasing yields would be profitable. The results obtained in 1928 also failed to show any correlation between these treatments and seed-piece decay as reported by Clayton (2). Neither was there any correlation between seed-piece decay and vigor of the vines as judged either by green weight of the tops or total yield.

General considerations.—Seed treatments to control scab and Rhizoctonia are generally recommended for Nebraska because of the prevalence of these diseases on the available seed tubers. Where soils are heavily infested, the beneficial effects of the treatment will be greatly reduced. Inasmuch as it is almost impossible to obtain potatoes entirely free from both diseases, and as the cost of such treatment is comparatively small, the use of a seed treatment is to be recommended for all seed potatoes. An increase of only one or two bushels of healthy potatoes per acre will repay the cost of the treatment.

While mercuric chloride gave satisfactory control of Rhizoctonia as judged by increased yields, the lack of effectiveness of this treatment in controlling scab places it second to hot formaldehyde as a general seed potato treatment for all sections of Nebraska. It could be used to great advantage in the eastern part of the state where Rhizoctonia is the more severe disease than in the western portion where scab is more prevalent.

Hot formaldehyde is recommended for general use because of its greater effectiveness in controlling both diseases. The treatment should be made a month before planting, if possible, to overcome the retarded emergnce sometimes caused by the treatment. This treatment is the only one tested that conrolled scab satisfactorily.

The organic mercury treatments have failed to control scab and while these treatments have increased yields thru the control of Rhizoctonia, they were not so effective as mercuric chloride and hot formaldehyde. They have also failed to show increased yields due to stimulation or seed-piece preservation. They also had the added disadvantage of causing seed-piece injury if the seed was not handled carefully. If cut seed is treated, it must be allowed to heal over before treatment and to dry off rapidly after treatment. If treated whole, injury may occur after cutting if the cut surfaces come in contact with the treated surfaces and are held under moist conditions for any length of time. It is possible to use these treatments without injury if proper care is taken regarding these points.

Some of the organic mercury treatments were used as a dust and others as a dip. There was little difference in the results as regards the control of the diseases studied. The dust method is rather cumbersome unless special equipment is available and does not seem to have any advantage over the dip method. The danger of seed-piece injury is even greater with the dust treatment of cut seed unless the cut surface has healed over, so as to be completely dry.

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